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Review

Aneurysmal Disease of the Main Arteries

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Abstract
The high incidence of aneurysms of different arterial systems in case of abdominal aortic aneurysm causes the need for the examination of all patients with aortic aneurysm in order to detect aneurysmal process in all main arteries. The use of the mentioned predictors of aneurism wall failure in daily clinical practice provides an opportunity to improve the results of surgical treatment. Active surgical approach in relation to aortic aneurysm and main arteries is indicated in the presence of aneurismal disease. The choice of treatment depends on the severity of the patient's condition, clinical manifestations, localization of the aneurysm and its morphology, with the preference for endovascular approach.

Keywords
aneurysms; aorta; arterial systems; main arteries; matrix metalloproteinase

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Discussion

Aortic aneurysms are a permanent, limited dilation of the vessel exceeding their normal sizes by 50% or more, are fraught with the development of various dangerous complications (dissection, rupture, thrombosis, thrombembolia). The incidence of aortic aneurysm (A) among the vascular diseases constitutes 3.4-6.7% and tends to further increase [4, 5]. The increase in the number of aneurysmal disease (AD) of various arterial systems begins with the increase in the number of cardiovascular diseases, improved diagnostic methods as well as increase in vascular traumatization (motor vehicle accidents, home traumatism, violent conflicts, iatrogenic injuries, diagnostic and therapeutic endovascular interventions) [17].

According to A.V. Pokrovskyi, the detection frequency of different arterial systems A in case of abdominal aortic aneurysm reaches 33.9% [14]. According to Yu.V. Cherviakov and co-authors, for the period from 1993 to 2009 51 patients (20.5%) suffered from AD of aortic and other major arteries branches among treated 248 patients with abdominal aortic aneurysm and thoracoabdominal aortic aneurysm [16]. These data indicate the similarity of the pathological processes in the aorta and main arteries of different locations.

The Ebers Papyrus written about 2000 years ago BC does not provide any information on arterial A description, but there are recommendations for their elimination. "It should be treated with a knife and burned with fire so that the hemorrhage is small". The first mention of splanchnic arteries aneurysms (SAA) in the medical literature refers to 1770. More than 3500 cases of SAA have been reported since that time [15].

Arterial wall damage in AD is often of generalized nature and has progressive course. Such type of vascular wall damage is called aneurysm [16].

Common cause for arterial aneurysms development is trauma, followed by atherosclerosis. Postoperative and dysplastic A are less common. Infectious (mycotic) aneurysm is even rarer. Arterial A development in women is caused by fibromuscular dysplasia.

Causes of SAA development include atherosclerosis, fibromuscular dysplasia, collagen fibers dysmorphology, reduction of muscle fibers, trauma, infection, inflammation, vasculitis [24].

Frequent symptoms of arterial A are the presence of pulsating formation, rarely pain in the area of arterial A and chronic limb ischemia (35-44%). Acute ischemia of tissue is observed in 11% of cases. Asymptomatic A are detected in 6% of cases [11]. Clinical manifestations of profunda femoris artery A growth are absent. Clinical picture appears only when A becomes large in size manifesting in a subjective pulsation feeling in the thigh, numbness of thigh medial surface due to nerve compression and swelling of the lower limbs due to venous compression which in some cases is complicated by deep vein thrombosis [6, 27, 30].

Bilateral A lesion of popliteal artery is ascertain 47-63% of cases [9]. Clear prognostic criteria of A growth, violations of its wall integrity and prevention of aneurysmal lesions of other arterial systems are not observed [4]. Splenic artery aneurysms are the most frequent among SAA; hepatic artery aneurysms rank the second place; aneurysms of gastroduodenal arteries, pancreaticoduodenal arteries and pancreatic arteries are less common; superior mesenteric artery and celiac trunk arteries aneurysms are even rarer [15, 24, 35].

The range of clinical manifestations is limited and nonspecific. Patients complain of abdominal pain of different localization and nature, abdominal discomfort. Abdominal cavity organs diseases (acute and chronic pancreatitis, cholelithiasis,

tumors, etc.) have been previously diagnosed in these patients [18, 34].

False aneurysms (FA) are very common complications associated with implantation of a synthetic prosthetic device. One of the main primary factors of anastomotic false aneurysms development is degenerative changes of the arterial wall due to the progression of the underlying disease. Infectious complications are believed to be the most important in the occurrence of early FA [2]. Other authors consider the use of synthetic materials to cause FA. Different extensibility degree of prosthetic device and artery in the area of the anastomosis may lead to the cutting of the artery wall with subsequent FA development. The value of hydrodynamic impact in anastomosis area and the effect of arterial hypertension and high peripheral resistance to the possibility of FA development are analyzed in the literature [13]. Technical aspects of the surgery (not deep injection into the vascular wall, overexertion during anastomotic sutures putting) are also of certain value [13].

The frequency of FA formation in the area of vascular anastomosis reaches 20% and has no tendency to decrease and mortality ranges from 5.8 to 17.2% in repeated operations [5, 13].

The opportunity to determine topographic and anatomic features of the process with great objectivity, to study the structural changes in A wall has appeared due to the widespread practical application of contrast-enhanced multispiral computed tomography.

The approach to the solution of the issue concerning abdominal aortic aneurysm (over 7 cm) is rather clear, however, the solution of the issue regarding smaller A is ambiguous. Earlier accepted approach has not proved its value. It consists in determination of the growth dynamics and surgery performance in case of an increase in the maximum transverse size over 6 mm per year. According to the statistics results the rupture of aortic A up to 5 cm was noted in 5-7% of patients and with the size of 5-6 cm in 15-18% of patients per year. Moreover, quickly progressing A growth (> 6 mm) was observed only in 3-4% of patients [17, 23].

Having assessed the factors affecting the risk of rupture of abdominal aortic aneurysm, in 2003 D.C. Brewster and co-authors grouped them and classified into low, medium and high risk levels. They advised to adhere to this classification in choosing the approach of such patients' treatment [19]. According to A. A. Nikonenko and co-authors, the volume of internal aneurismal thrombotic masses as a morphological criterion, namely the predictor of rupture of small size A aorta is leading in pathogenesis. Internal aneurismal thrombotic masses have been clinically proven to have a high proteolytic activity towards extracellular stromal structures of the intima-media and are directly proportional to the risk of A dissection or rupture. However, specific quantitative indicators of metabolic proteolysis in AD as an element of control and factor for the prognosis of process development have not been identified up to this day. Nevertheless, according to A. A. Nikonenko and co-authors, intraluminal thrombotic masses were the criterion for small A ruptures in 10% of cases [12].

A number of researchers indicate correlation between the frequency of A ruptures and the severity of the systemic inflammatory response [8, 9, 25]. Raffetto and colleagues have noted an increase in the concentration of interleukin (IL) 1 and 6 in plasma by 1.5 times 24 hours before the actual A rupture [31]. Rozavian and co-authors have noted that the highest indices of IL-6 and tumor necrosis factor α are observed in 1-2 days after the surgery for abdominal aorta prosthesis with subsequent stabilization of their levels during 5-7 days [32].

One of the sensitive tests to determine the risk of A rupture through quantitative analysis of macrophages proteolytic activity is determination of the metabolic predictors concentration in plasma, namely matrix metalloproteinases MMP-2 and MMP-9 [4, 31, 36].

Concerning the possible biochemical and histological markers in the origin, development and progressing of AD of different main arteries, A is histologically characterized by destruction of elastin and collagen in media and adventitia as well as the loss of smooth muscle cells with thinning of the middle layer. In addition, wall infiltration by lymphocytes and macrophages with neovascularity has been noted [8, 13]. The process is mainly localized in the intima and media in case of atherosclerosis, whereas pathology affects media and adventitia in case of A.

Combination of different factors such as local hemodynamic overload, destruction of middle layer proteins, genetic disposition play a specific pathogenetic role in AD occurrence [8]. Such mechanisms of innate immunity as Toll-like receptors are involved in the ways of atherogenesis initiation [1]. Activation of these receptors triggers different intracellular pathways of signal transmission to the synthesis of proinflammatory cytokines. Intense activation of inflammation may be an important risk factor for atherosclerosis [7, 22, 33]. The release of active substances leads to an increased migration of leukocytes into the aortic wall with the subsequent release and activation of metalloproteinases. Proteinases, in their turn, lead to degradation of the middle layer, aneurysmal dilatation and hemodynamic vascular remodeling [25]. Hemodynamic overload of aortic walls in A area enhances the proteolysis, leads to dilatation progression and subsequent rupture [9].

Occurrence and progression of A is now decided to be associated with four basic mechanisms, namely proteoclastic degradation of arterial wall connective tissue, inflammation and immune reactions in the wall, biochemical stress, and molecular genetics [37].

Studies and observations of A results have showed that the risk of its rupture is affected by obstructive lung disease, smoking, hypertension and heredity in addition to A diameter, shape, rate, volume increase [8, 19].

Taking into account the high risk of A rupture, treatment of symptomatic and asymptomatic arterial aneurysm along with fatal bleeding is necessary. Treatment choice depends on the patient, clinical symptoms, and its localization and

Table 1. The risk of abdominal aortic aneurysm ruptures according to D.C. Brewster

Risk factors	Risk level		
	Low	Medium	High
Diameter of abdominal aortic aneurysm	<5 cm	5-6 cm	>6 cm
Aneurysm growth rate	<0.3 cm/year	0.3-0.6 cm/year	>0.6 cm/year
Smoking / COPD	No	Moderately severe	Severe/ steroids
Family history	No relatives	One relative	Many relaives
Hypertension	no	Controlled	Poorly controlled
Form	Fusiform	Sacciform	Accentric
Wall stress	low (35 N/cm)	Medium (40 N/cm)	High (45 N/cm)
Sex	-	Male	Female

morphology.

Five-year survival of patients with abdominal aortic aneurysm without surgery constitutes 18% and in operated patients this figure is 90-60%. A are often located in the abdominal aorta and iliac arteries, rarely in the femoral and popliteal ones. Posterior tibial artery and brachial artery are less affected.

Yu.V. Cherviakov and colleagues treated 39 (15.8%) patients with iliac arteries aneurysm (one third of them was with bilateral lesions), 37 (14.9%) patients with aneurismal lesions of the femoral arteries (one third of them was also with bilateral lesions), and 14 (5.2%) patients with lesion of the popliteal-tibial segment among 248 patients with abdominal aortic aneurysm and thoracoabdominal aortic aneurysm [16]. Aortography of two patients with multiple bilateral aneurysmal lesions of the aorta, iliac, femoral and popliteal arteries who were observed in 2015-2016 is provided below. Among 471 patients operated at the Scientific Center of Cardiovascular Surgery, linear aortic prosthesis concerning A lesions was conducted in 198 (42%) patients, aortoiliac prosthesis was performed in 165 (35%) patients, aorto-femoral bifurcation prosthesis was applied in 108 (22.9%) patients [3]. The greatest number of complications and symptomatic manifestation of abdominal aortic aneurysm was observed in the group of patients with aneurysms more than 7 cm in size [3].

Resection with the affected artery replacement is usually performed. Resection of A with pleural suture of the artery and by-pass technique is applied rarely. Resection of A with arterio-arterial end-to-end anastomosis or end-to-side anastomosis as well as lateral patchplasty after A resection are used more rarely. Extraanatomic bypass is conducted in case of infectious (mycotic) aneurysm [5, 6].

However, the surgical treatment of aortic aneurysm has a number of disadvantages such as high surgical injury rate, high postoperative mortality reaching 3 to 12.5 %. In addition, a wide range of comorbidities among older people limits the possibility of open surgical treatment. Thus, the mortality rate among patients operated on for abdominal aortic aneurysm constitutes 4% in patients under 55 and increases to 10% among patients older than 75 [20].

The average in-patient mortality constitutes 3.8-9.2% in case of abdominal aortic aneurysm resection and 1-2% in endoprosthesis replacement. Endovascular technologies of aortic aneurysm and main arteries aneurysm have developed from application of linear endoprostheses to the creation of bifurcation aorto-femoral stent-graft [20, 26].

Endoprosthesis replacement provides an opportunity to avoid fatal outcomes in severe patients with aortic aneurysm and main arteries aneurysm. Endovascular interventions include removal of aortic or main artery A from blood flow, embolization of A cavity, artery embolization distal and proximal to aneurysmal neck, endoprosthesis replacement, stent-assisted occlusion [21].

Naganuma M. and co-authors reported about successful treatment of 534 patients with splenic artery A treated at 229 hospitals in Japan. The patients underwent transcatheter A embolization. Early postoperative complications were observed in 6% of cases [29].

Melissano G. and co-authors successfully treated 26 patients with hepatic artery A in size from 2 to 17 cm. 17 patients underwent open surgery and 9 patients underwent endovascular treatment (5 of them underwent platinum coil embolization of aneurysm, and stent-graft was performed to 4 patients) [28].

Thus, a high detection rate of aneurysms of different arterial systems in case of abdominal aortic aneurysm causes the need for the examination of all patients with aortic aneurysm in order to detect aneurysmal process in other main arteries. Active surgical approach in relation to aortic aneurysm and main arteries is indicated in the presence of aneurismal disease. The choice of treatment depends on the severity of the patient's condition, clinical manifestations, localization of the aneurysm and its morphology, with the preference for endovascular approach. The use of the mentioned predictors of aneurism wall failure in daily clinical practice provides an opportunity to improve the results of surgical treatment.

Summarizing the facts presented above, it can be noted that more and more new data on aneurysm growth and its wall integrity violation constantly emerge. This provides new opportunities to reconsider the diagnosis and surgical treatment of aneurysmal disease of the main arteries.

Clear pathogenesis of A lesions of various arterial systems providing the opportunity to ensure pathogenetically

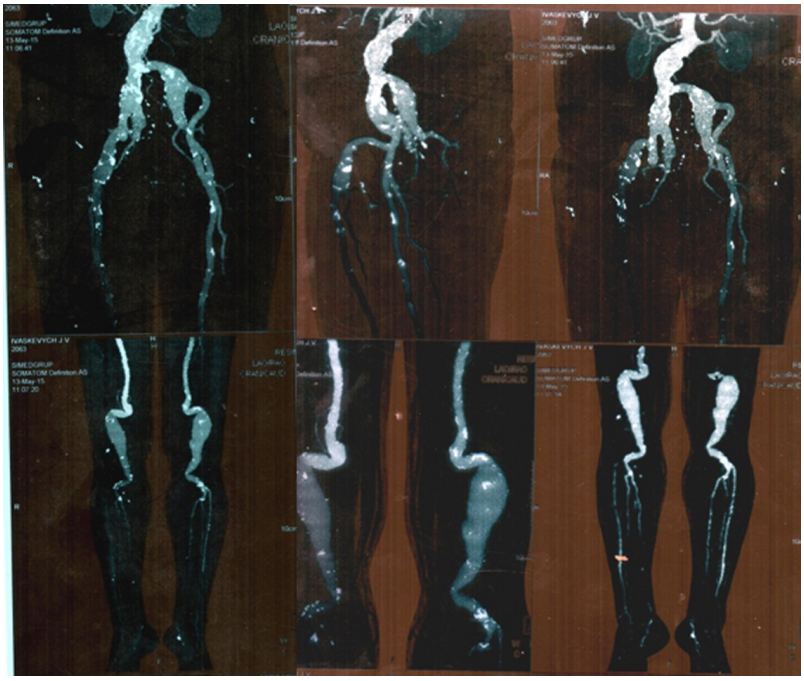

Figure 1. The patient Ivaskiv Yosyp Volodymyrovch, 1936 year of birth (case history #1943615).

based drug correction and prevention of AD have not been determined so far.

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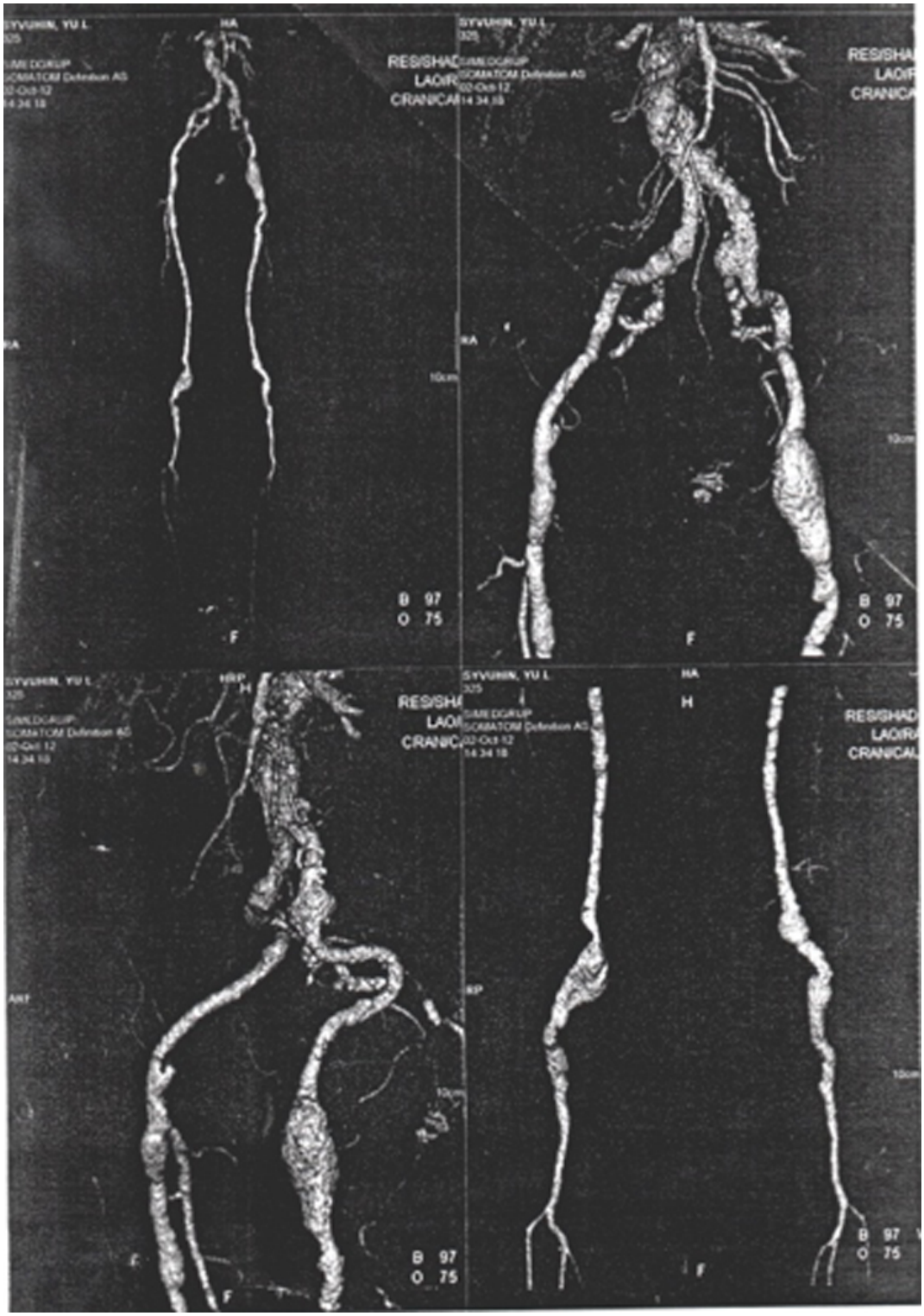

Figure 2. The patient Syvukhin Ihor Mykhailovych, 1957 year of birth.

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